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IPR gender gaps: a first look at utility model, design right and trademark filings

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Abstract

This study extends the analysis of the gender gap in patenting into design rights, utility model (UMs) and trademarks (TMs), which are complementary methods for protecting intellectual property. The analysis is descriptive and uses register data from the Finnish patent and registration office covering the years 1982–2013. A persistent gender gap is found for all intellectual property rights. The gap has narrowed over time for national patent, design right and TM filings but not for UM filings. It is found that, in comparison to men, women are relatively less often single inventors or designers and more often members of inventor or designer teams.

Keywords Patent · Utility model · Design right · Trademark · Gender

JEL Classification J16 · O31 · O32 · O34

Introduction

The patent system is an institution whose objective is to incentivize innovation activity (Scotchmer 2004; WIPO 2008)—that is, investments in research and development (R&D), the licensing of inventions, the commercialization of inventions, and the diffusion of technological knowledge via patent databases. Behind every invention there is an inventor or an inventor team. Micro-level decisions by firms and individuals to invest in R&D determine the macro-level rate and direction of innovation. This is why it is important to analyze who becomes an inventor and what are inventors' motives (Rossman 1931; Machlup 1962; Harhoff and Hoisl 2007; Väänänen 2010; Toivanen and Väänänen 2012, 2016; Hoisl and Mariani 2016; Akgigit et al. 2017; Bell et al. 2017; Aghion et al. 2018).

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Inventors who apply for patents have been predominantly male (Whittington and Smith-Doerr 2005; Ding et al. 2006; Mattes et al. 2006; Whittington and Smith-Doerr 2008; Frietsch et al. 2009; Whittington 2011; Toivanen and Väänänen 2012; Hunt et al. 2013; Toivanen and Väänänen 2016; Martinez et al. 2016; Hoisl and Mariani 2016). This gender imbalance may indicate that the society is not making full use of its entire talent pool in innovative activity (Bell et al. 2017). Therefore, it is of great importance to track and analyze the gender gaps in the context of IPRs. Finland provides a particularly interesting case as it is among the most gender equal countries in the world and has advanced IPR institutions.

The contribution of present study into existing literature is twofold. First, present study extends the “patent gender gap” analysis to other intellectual property rights. To our knowledge, this is among the first studies to analyze gender gaps in the filing of design rights, utility models (UM) and trademarks (TM). Like patents, UMs and design rights are rights to exclude others from commercially using the protected subject. In contrast to patents, they typically protect only physical products and not processes or methods. Design rights are a means of protecting the aesthetic aspects of products (WIPO 2008; Filitz et al. 2015; Filippetti and D’Ippolito 2017), whereas utility models are fast protection methods for small and incremental inventions (Beneito 2006; WIPO 2008; Heikkilä and Lorenz 2018; Heikkilä and Verba 2018). TMs are, instead, protection methods for brands but they have also been used as an indicator for innovations (Mendonca et al. 2004; Block et al. 2015; Schautschick and Greenhalgh 2016; Castaldi 2018). Second, this study contributes to existing literature on gender-specific collaboration patterns by analyzing gender composition of inventor and designer teams. Studies have thus far shown that women tend to invent in larger patent inventor teams (Mauleón and Bordons 2010; Sugimoto et al. 2015; Hoisl and Mariani 2016; Martinez et al. 2016; Meng 2018). We extend the analysis of collaboration patterns into design rights and UMs.

Literature review and research questions

A patent is a right to exclude others from the commercial use of the protected invention. Thus, a patenting decision is a signal that the applicant considers the invention to have commercial potential. Patents are also a means of convincing investors to invest in the commercialization of the invention and can be used as collateral in acquiring funding (Long 2002; Hsu and Ziedonis 2013; Hoenen et al. 2014; Hoenig and Henkel 2015). It should be noted that only a small proportion of patented inventions are valuable—that is, the patent value distribution is highly skewed (Scherer and Harhoff 2000; Åstebro 2003; Giuri et al. 2007). Most patented inventions end up being commercial failures, while the relatively few successful patented inventions yield large returns.¹

Although there is no reason to expect a gender difference in creativity or ability, most patentees have hitherto been male. Gender-specific choices in education and the low share of female engineers (e.g., Hunt 2010; Mauleón and Bordons 2010; Hunt et al. 2013; Väänänen 2010; Toivanen and Väänänen 2016) are, presumably, among the root causes

¹ Patents and other IPRs can also be utilized strategically (see, e.g., Blind et al. 2006; Torrisi et al. 2016) in several ways that are not discussed in this context. Patents that are not used for commercialization purposes but, for instance, to pre-empt competitors from patenting (Torrisi et al. 2016) are likely to increase the skewness of patent value distribution.

of the patent gender gap. Women are less likely to choose science, technology, engineering, and mathematics (STEM) education, and they also disproportionately quit engineering jobs (Hunt 2010). Interestingly, there exists a “gender-equality paradox”: the higher the nation’s gender equality, the higher the sex differences in the magnitude of relative academic strengths and pursuit of STEM degree (Stoet and Geary 2018). While the number of women holding degrees in technology has increased globally, their share of patentees has grown proportionally less (Martinez et al. 2016).

The share of female inventors among all patent inventors has increased over time, and the gender gap in patenting has narrowed (Ding et al. 2006; Whittington and Smith-Doerr 2008; Frietsch et al. 2009; Mauleón and Bordons 2010; Jung and Ejermo 2014; Sugimoto et al. 2015; Martinez et al. 2016; Bell et al. 2017).² For instance, Giuri et al. (2007) report that only 2.8% of the inventors in a large European patent inventor survey (PatVal) are women. Frietsch et al. (2009) report that the share of female patent inventors in patent applications at the European Patent Office (EPO) by inventors from 14 selected countries in 2005 ranged from 2.9% in Austria to 14.2% in Spain. According to Martinez et al. (2016), the share of women inventors in Patent Cooperation Treaty (PCT) filings increased from 9.5% in 1995 to 15% in 2015. During the same period, the share of PCT filings with at least one female inventor increased from 17 to 29% (Martinez et al. 2016). One of the United Nations’ 17 Sustainable Development Goals is to “Achieve gender equality and empower all women and girls” (Goal 5).³ The World Intellectual Property Organization (WIPO) is a specialized agency of the United Nations and “committed to promoting gender equality in the field of intellectual property” (Martinez et al. 2016). Martinez et al. (2016) have calculated that gender balance in PCT patent filings will not be observed before 2080 if the current progression rates are maintained. Bell et al. (2017) report that 13.1% of over 1.2 million inventors listed in U.S. patent applications filed between 2001 and 2012 or granted between 1996 and 2014 were women. They estimate that it would take 118 years to reach gender parity in U.S. patent filings at the current rate of convergence. Several studies have also shown that women are underrepresented among academic inventors (Whittington and Smith-Doerr 2005; Ding et al. 2006; Murray and Graham 2007; Whittington and Smith-Doerr 2008). Moreover, Thursby and Thursby (2005) report that women researchers are less likely to disclose inventions than men.

The main research question of this study is: “Do gender gaps in design right, UM and TM filings differ from patent gender gaps?”. To our knowledge, there are no studies that analyze the gender gaps in the filing of these complementary IPRs. Design rights protect the aesthetic aspects of a product. Therefore, it is expected that there is not equally strong connection between engineering education and the likelihood of becoming a designer in a design right filing in comparison to the likelihood of becoming an inventor in a patent filing. Moreover, historically women have tended to specialize in inventing and patenting clothing and furniture-related inventions (Khan 2000), for which design right protection is particularly suitable. Design rights related fees are also lower than patenting fees and the likelihood of receiving a design right registration is higher than the likelihood of a patent grant.

² We acknowledge the difference between the terms “sex” (biological) and “gender” (identity). However, to be consistent with prior patent gender gap studies, we use the term “gender” throughout the paper.

³ Source: <http://www.un.org/sustainabledevelopment/sustainable-development-goals/> Accessed on 1st October 2017.

Regarding UMs, the link between gender and the number of filings is not clear. UMs are cheaper than patents and the inventive step requirement is lower. On one hand, the same reasoning as that for design rights could apply. The gender gap should be smaller, since UMs are a means of protecting incremental inventions and advanced education in engineering should have less effect on the likelihood of becoming a UM inventor. The examination of UMs is not comparable to patent examination process, but it is rather a registration. As in the case of design rights, filing a UM is less risky and could therefore attract relatively more women. On the other hand, UMs are especially designed for individual inventors which are often inventor-entrepreneurs and according to empirical evidence most entrepreneurs are men (e.g., Koellinger et al. 2013; Bönte and Piegeler 2013). Thus, the gender gap in UM filings could equally well be higher in comparison to patents.

TMs protect brands and we expect to find the smallest gender gap for them since inventing a novel TM does not require engineering education. On the other hand, entrepreneurs are probably common applicants of TMs and most entrepreneurs are men. Therefore, it is challenging to predict the magnitude of gender gap in TM filings.

Martinez et al. (2016) reviewed the literature on the composition of inventor teams in patent families, whose main observations are that women are more likely than men to be members of larger inventor teams and less likely to be single authors or inventors. Mauleón and Bordons (2010) found that, compared to men, women are more likely to collaborate and less likely to be single inventors. McMillan (2009) studied U.S. patents owned by U.S. biotechnology companies and reported that 4% of patents had female only inventor teams, 64% male only teams and 32% teams with both female and male inventors. Hoisl and Mariani (2016) reported that women are members of larger inventor teams (mean 3.3) more commonly than men (mean 2.6). Sugimoto et al. (2015) documented that women have more co-inventors in all technological fields (International Patent Classification, IPC). Meng (2018) studied gender patterns in U.S. patents and provided evidence that women invent in larger inventor teams compared to men also in the field of nanotechnology. To our knowledge, no prior study has analyzed whether gender-specific collaboration patterns between patents and other IPRs differ. This paper aims to fill this gap by analyzing inventor and designer team compositions in patents, UMs and design rights. The second research question is: “Do gender-specific collaboration patterns differ between patents, UMs and design rights?”

Empirical analysis

Institutional context

Three factors make Finland a particularly interesting case country. First, Finland has advanced IPR institutions. Finland’s IPR system has been ranked among the strongest in the world by the World Economic Forum (WEF; see Schwab 2017). The first Finnish patent was granted as early as in 1842 and the first trademark registration in 1889, the design rights system was established in 1971, and the utility model system was set up in 1992. Second, the fact that Finland has a UM system, makes it possible to analyze whether UM gender gaps differ from patent gender gaps. It should be noted that not all countries have UM protection and that UM systems differ between countries. Compared to patents, Finnish UMs have shorter maximum term (10 years), lower inventive step requirement and

no substantive examination of applications at the patent office. Third, Finland is one of the most equal countries in the world, with the narrowest gender gaps between men and women in many areas of life (Plantenga et al. 2009; WEF 2016; Statistics Finland 2016; EIGE 2017).⁴ According to WEF (2016), Finland has the second smallest overall gender gap in the world (Iceland being the most gender equal). According to the European Institute for Gender Equality (EIGE 2017), Finland ranked third after Sweden and Denmark in the Gender Equality Index among 28 European Union countries in 2015.

Finland's legislation regarding employees' inventions is similar to that of Germany (cf. Harhoff and Hoisl 2007). Employees are obliged to disclose their inventions, and employees must be compensated if they come up with new inventions and the firm commercializes these inventions (applies for a patent; see, Toivanen and Väänänen 2012).⁵ A more comprehensive overview of the institutional context is provided in the Online appendix.

Data

Finnish IPRs

PRH provided register data on all Finnish patents, UMs, design rights and TMs. The data include the names of inventors, designers, and applicants. PCT patent filings at PRH are excluded to keep the focus on national filings when analyzing gender gaps. In the case of TMs, we focus on applicants since the register does not name an “inventor” or “designer” of TMs. For patents, the raw data cover 1970–2013, for UMs 1992–2013, for design rights 1971–2013, and for TMs 1993–2013.⁶ The data provided by PRH do include the nationalities of applicants for design rights, but the information is missing in the case of patents and UMs. Hence, we complemented the data of PRH with EPO's PATSTAT (Worldwide Patent Statistical Database, April 2016 edition) data, to acquire more information on inventors. PATSTAT contains information on the countries of residence of applicants and inventors. Country of residence is not the same as nationality, but it is the best available proxy. Hence, we limited our attention to inventors whose country of residence was Finland. Since the information on the countries of residence is incomplete for patent applications filed in the 1970's and early 1980's, the final sample of patents covers 1982–2013.

Names

According to the Finnish Names Act (Nimilaki 9.8.1985/694, 32 b §), “a name cannot be approved as a forename [...] if the name is a woman's name given to a boy or a man's name given to a girl.”⁷ Thus, the first name of a Finn is a direct indicator of his or her biological sex and a proxy for his or her gender identity. For the sake of consistency with previous

⁴ For further information, see Statistics Finland: Gender equality http://www.stat.fi/tup/tasaarvo/index_en.html Accessed 2nd November 2017.

⁵ http://www.wipo.int/wipolex/en/text.jsp?file_id=127119 Accessed 16th October 2017.

⁶ We limit the trademark sample to this period since before 1993 the register had incomplete information on applicants.

⁷ <http://www.finlex.fi/en/laki/kaannokset/1985/en19850694.pdf> English translation of the Finnish Names Act. Accessed 6th November 2017. See also University of Helsinki Almanac Office: <https://almanakka.helsinki.fi/en/name-days/finnish-names-act.html> Accessed 6th November 2017.

patent gender gap studies, this study uses the term “gender”, although, in fact, the identifier is for sex.

Recently, Martinez et al. (2016) created a database by which the gender of the inventors could be identified. Following Sugimoto et al. (2015), they used Wikipedia’s name lists as information sources for names and genders. In this paper, we use publicly available data from the Population Register Centre of Finland (Väestörekisterikeskus, VRK)⁸ to classify inventors as male or female. Our gender attribution is based on merging IPR data and name data.⁹

According to VRK, some names have been given to both males and females. We calculated the share of females of the total number of Finns having each of these names. If the female share was < 10% for a specific name, we classified all inventors with this name as males, and if the female share was > 90%, we classified all inventors with this name as females. If the female share was more than 10% but less than 90%, the inventor or designer was considered “unattributed” and excluded. Finally, the gender attribution was checked one by one for each name. Inventors, who could not be classified in this final checking as female or male, were excluded.¹⁰

Timing issues

IPRs have different grant lags, and patents, in particular, take a long time to be granted (Harhoff and Wagner 2009; Heikkilä and Lorenz 2018). Hence, for the sake of consistency and comparability, IPRs are classified by their application date at the PRH. In the case of patents, UMs and design rights, we focus on priority filings and exclude subsequent filings (cf. de Rassenfosse et al. 2013). A priority filing is one for which the applicant does not claim any priority filings—that is, earlier filings for the same invention or design at some other patent office or at PRH. Filings that claim a priority filing are subsequent filings. Since the Finnish UM system was established in 1992, we focus on the time period 1992–2013 when analyzing co-inventing patterns of patents, UMs and design rights. Final sample includes 103,344 patent inventors (1982–2013), 14,299 UM inventors (1992–2013), 13,667 design right designers (1982–2013) and 6218 individual TM applicants (1993–2013).

Descriptive findings

IPR gender gaps

Figure 1 shows the share of female inventors in patent and UM filings, the share of female designers in design right filings and the share of female applicants in TM filings at the Finnish patent office. Note that the shares refer to inventors, designers and applicants for whom gender could be attributed.

The average annual share of Finnish patent inventors with Finnish female names during 1982–2013 was 7.0%, rising from 2.0% in 1982 to 8.0% in 2013. The average annual share of Finnish designers with female names in design right filings during

⁸ Available as open data at: <https://www.avoindata.fi/data/en/dataset/none>.

⁹ See Raffo and Lhuillery (2009) for discussion and evaluation of patent data (PATSTAT) name-matching procedures.

¹⁰ 2251 (2.13%) patent inventors, 92 (0.6%) UM inventors, 196 (1.4%) design right designers and 191 (3%) individual TM applicants were excluded.

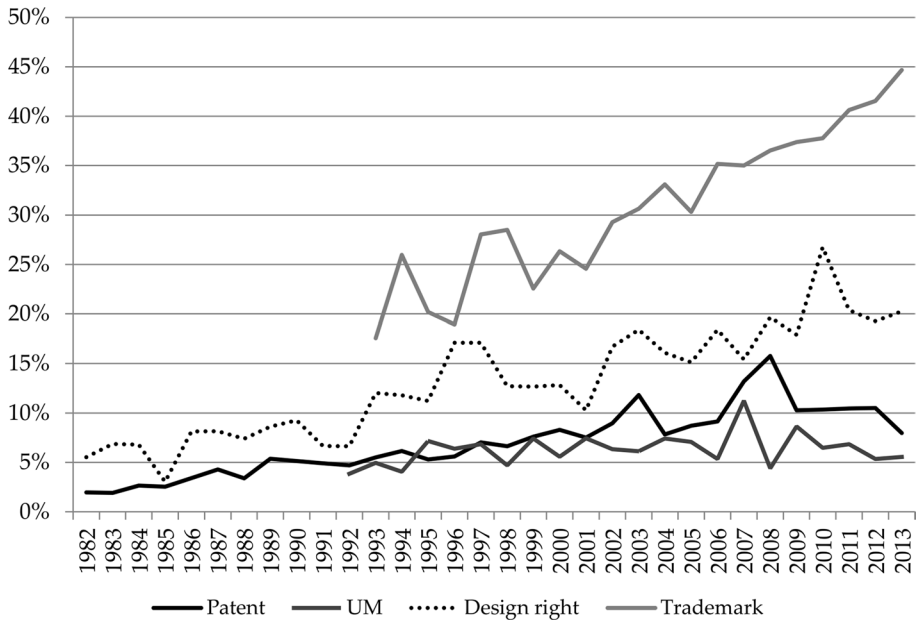


Fig. 1 The share of female names 1982–2013. *Notes:* Inventors, designers and applicants, for whom gender could not be attributed, are excluded. Patents do not include PCT filings filed at PRH. For TMs, the data is limited to individual applicants for which it is possible to attribute gender (i.e., non-individual applicants excluded)

1982–2013 was 13.1%, rising steadily from 5.5% in 1982 to 20.3% in 2013. Interestingly, the average annual share of Finnish UM inventors with Finnish female names during 1992–2013 was only 6.3% and it remained relatively constant over time. Surprisingly, it seems that the share of patent inventors with female names has begun to decrease after a spike in 2008, when 15.8% of inventors in patent applications had female names. The gender gap is smaller in design right filings than in patent filings but it is larger in UM filings relative to patent applications. In TM filings, the share of female individual applicants has increased most rapidly doubling from less than 20% in 1993 to nearly 45% in 2013. The average share of individual applicants with female names between 1993 and 2013 was 30.7%.

Figure 3 in the “Appendix” shows that specialization across technological sectors in patents and UMs differ systematically between men and women and there has been little change between 1992 and 2013. They also show, in line with prior studies (Fritsch et al. 2009; Mauleón and Bordons 2010; Sugimoto et al. 2015; Hoisl and Mariani 2016), that female share of patent inventors is relatively highest in chemistry. Men, in contrast, tend to focus relatively more on mechanical engineering inventions both in patents and UMs. The low share of female inventors in engineering sectors reflects the educational sorting by gender: According to Statistics Finland, in 2016, female share of Finns that had obtained tertiary education in the engineering, manufacturing, and construction sector was 14.6% (see Online appendix). Figure 4 in the “Appendix” illustrates how gender gaps have evolved in patent and UM filings. The narrowing gender gap in patenting has been driven by increased patenting by female inventors in chemistry and instruments sectors.

Table 1 Descriptive statistics

Variable	Sample										Difference Mean (Men)– Mean (Women)	T-stat		
	Total					Men								
	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs			Mean	SD
<i>IPR</i>														
	80,702	0.087	0.282	7047	0.913	0.282	73,655	0.694	0.461	73,655	2.855	2.13	– 0.219***	– 39.163
Female indicator	80,702	0.713	0.452	7047	4.974	3.558	73,655	2.855	2.13	73,655	0.751	0.432	– 2.119***	– 74.201
Co-invent	80,702	3.040	2.367	7047	0.702	0.458	73,655	0.751	0.432	73,655	0.751	0.432	0.049***	9.095
Team size	80,702	0.747	0.435	7047										
Non-individual applicant														
<i>Patent</i>														
	14,285	0.063	0.243	902	0.501	0.500	13,383	0.413	0.492	13,383	1.773	1.289	– 0.088***	– 5.220
Female indicator	14,285	0.418	0.493	902	2.461	3.628	13,383	1.773	1.289	13,383	0.548	0.498	– 0.688***	– 12.950
Co-invent	14,285	1.816	1.553	902	0.341	0.474	13,383	0.548	0.498	13,383	0.548	0.498	0.206***	12.090
Team size	14,285	0.534	0.499	902										
Non-individual applicant														
<i>Design right</i>														
	7291	0.145	0.352	1057	0.273	0.446	6234	0.253	0.435	6234	1.413	0.951	– 0.112***	– 3.325
Female indicator	7291	0.256	0.437	1057	1.525	1.313	6234	1.413	0.951	6234	0.569	0.495	0.148***	8.965
Co-invent	7291	1.429	1.012	1057	0.421	0.494	6234	0.569	0.495	6234	0.569	0.495		
Team size	7291	0.547	0.498	1057										
Non-individual applicant														

The time window is 1992–2013. Inventors and designers to whom gender could not be attributed are excluded. “Non-individual applicant” refer to cases in which the patent has been applied not by an individual inventor, but by firms, governments, universities, or hospitals. *, **, and *** refer to 0.1, 0.05 and 0.01 significance levels, respectively

Co-inventing and team compositions

This section analyzes the characteristics of teams in which Finnish men and women invent novel technical inventions and designs. TMs are not considered because the register data of PRH reports only one applicant per a TM and contains no information on collaboration. Since the UM system was established in 1992, all descriptive statistics, figures, and results consider the period 1992–2013. Table 1 presents the descriptive statistics.

Table 1 reveals some interesting patterns. The share of women inventors in patent applications over the period was 8.7% and in utility model filings 6.3%. The share of women designers in design right filings was 14.5%. Regarding collaborative inventive activity, it is found that co-inventing was the most common among patent inventors (71.3%), followed by UM inventors (41.8%), and was least common among designers (25.6%). Women collaborate more often than men in all IPR types, but the difference is very small and not statistically significant in the case of design rights.

The average team size is the largest in patent filings, 3.0 inventors, while UMs have on average 1.8 inventors and design right filings a mean of 1.4 designers. If inventor team size is a good proxy for the value of the protected invention (cf. Breitzman and Thomas 2015) or design, then we would interpret that patents protect the most valuable and radical inventions, while UMs and design rights are means of protecting less valuable or incremental inventions and designs. Consistent with earlier studies (Sugimoto et al. 2015; Hoisl and Mariani 2016; Martinez et al. 2016) we find that women tend to invent and design in larger teams than men, the differences being statistically significant at a 0.01 significance level for all IPR types. Patents are more often applied for by non-individual applicants (i.e., by firms, government, universities, or hospitals; 74.7%) in comparison to UMs (53.4%) and design rights (54.7%). In comparison to men, women are relatively more often inventors and designers in filings by individual applicants. This distinction between individual and non-individual applicants is important because the risks and potential returns are likely to be differently allocated depending on the applicant.¹¹ The applicant can be assumed to be the one that tries to commercialize the invention, takes the related risks, and reaps the potential returns.

Figure 2 illustrates the team compositions of Finnish inventor and designer teams by gender, separately for each IPR type. Team compositions can be divided into five categories by gender shares: (1) “All female,” indicating that all team members have female names, (2) “More female,” indicating that majority of team members have female names, (3) “Equal gender shares” indicating that there are equal numbers of team members with male and female names, (4) “More male,” indicating that majority of team members have male names, and (5) “All male,” indicating that all team members have male names. McMillan (2009) conducted a similar analysis using a simpler three-category classification (female only, both, male only).

Figure 2 shows that majority of inventions and designs are creative output of teams in which all designers or inventors have male names. All male inventor teams are the most common in all IPR types, their share being 91.7% for patents, 93.5% for UMs, and 89.1% for design rights. Corresponding shares of all female inventor teams are 2.3, 4.9, and 9.4%, respectively. Interestingly, there are only very few filings with “mixed teams”—that is, teams with both male and female team members. Only 6% of patent inventor teams, 1.6% of UM inventor teams, and 1.5% of design right designer teams have both male and female team members.

¹¹ Unfortunately, with the data at hand, we are unable to identify inventor-entrepreneurs, that is, inventors who are also entrepreneurs in the firm that is assigned to be the applicant in the IPR application.

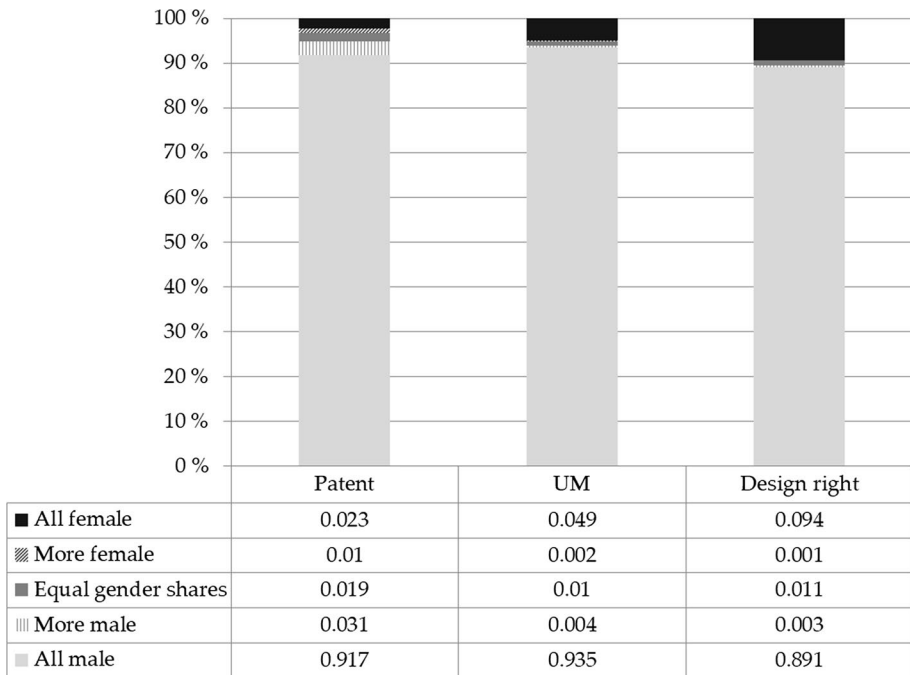


Fig. 2 Gender compositions of Finnish inventor and designer teams 1992–2013. *Notes:* The shares are reported for filings in which gender could be attributed for all inventors or designers. Hence, the sample is limited to teams in which all inventors are Finnish

Next, we analyze the association between gender and the likelihood of becoming a co-inventor conditional on being an inventor (or a co-designer conditional on being a designer). The following equation is estimated:

$$Y_{ijkt} = \alpha + \beta_1 \text{Female}_i + \beta_2 \text{Non-individual_applicant}_k + \theta_j + \eta_t + \varepsilon_{ijkt} \quad (1)$$

where Y_{ijkt} is a binary variable indicating whether the inventor (designer) i co-invents in filing k in technology field (Locarno class) j in year t . α is constant. Female_i is a binary variable: 1 if inventor (designer) i has a female name and 0 if a male name. $\text{Non-individual_applicant}_k$ is a binary variable: 1 if any of the applicants in filing k is not an individual and 0 if all applicants are individuals. θ_j is a technological field (Locarno class) indicator and η_t is an application year indicator. ε_{ijkt} is an inventor-filing-pair specific error term. Table 2 reports the results.

The estimates in Table 2 show a positive association between female name of the inventor (designer) and the likelihood of becoming a co-inventor (co-designer). The association is the strongest for patents and the weakest for design rights. Positive and significant estimates on *Non-individual applicant* suggest that firms apply IPRs relatively more often for inventions and designs that have been created in teams, whereas individual applicants file IPRs for inventions and designs that have a single inventor or designer. Robustness checks are reported in Table 3 in the “Appendix”. In them, team size is the dependent variable and negative binomial models are estimated. The robustness checks provide further evidence that female inventors and designers are more likely members in larger teams.

Table 2 Results: Likelihood of co-inventing and co-designing

Dependent variable	Pr(Co-invent = 1)	Pr(Co-invent = 1)	Pr(Co-design = 1)
Sample	Patent	UM	Design
Model	Probit	Probit	Probit
Estimate	ME	ME	ME
Female name	0.22*** (0.01)	0.14*** (0.02)	0.06*** (0.02)
Non-individual applicant	0.18*** (0.01)	0.18*** (0.01)	0.11*** (0.02)
Year fixed effects	Yes	Yes	Yes
Technology field fixed effects	Yes	Yes	
Locarno class fixed effects			Yes
N	80,702	14,285	7298
Pseudo R ²	0.11	0.07	0.08
Log pseudolikelihood	– 42,963.47	– 9044.62	– 3835.46

Reported estimates are average marginal effects. The time period is 1992–2013. Inventors and designers for which gender could not be attributed are excluded. Standard errors clustered at the filing level in parentheses. *** indicates 0.01 significance level

To sum up the empirical findings, it is found that, among Finnish inventors of Finnish IPRs, (1) there is a persistent gender gap in patents, UMs, design rights and TMs, (2) the gender gap is smaller for design rights and TMs in comparison to patents, (3) the gender gap is larger for UMs than for patents, (4) the gender gap has converged in patents, design rights and TMs but not in UMs over time, and (5) a common pattern for patents, UMs and design rights is that women are more likely to invent and design in teams than men, whereas men are relatively more often single inventors or designers.

Discussion and conclusions

This study provides descriptive evidence on the gender gaps in patent, UM, design right, and TM filings made by Finnish inventors at the Finnish patent office. It shows that the majority of Finnish inventors in patent and UM filings, designers in design right filings, and individual applicants in TM filings have been male. During 1992–2013, the gender gap was found to be smaller in design right and TM filings than in patent filings, but larger in UM filings relative to patent filings. The gender gap has decreased over time for patents, design rights, and TMs, but seems to be persistent in the case of UMs. Consistent with prior studies (Mauleón and Bordons 2010; Sugimoto et al. 2015; Hoisl and Mariani 2016; Martinez et al. 2016) it is found that, in the case of patents, women are more likely to invent in teams (“co-invent”) than men, whereas men are more likely to be single inventors. This study confirms the same pattern for UMs and design rights.

The current study focused solely on documenting gender gaps and collaboration patterns in IPRs and neglected the investigation of underlying mechanisms. Future research could use micro-level data on educational choices to investigate how large shares of the IPR gender gaps can be explained by them. Presumably, gender-equality paradox in STEM education (Stoet and Geary 2018) is associated with country-level IPR gender gaps. While

Finland is among the most gender-equal countries in the world, it has one of the world's largest gender gaps in college degrees in STEM fields (Stoet and Geary 2018) and the gender gap in patenting remains higher than in several countries (see Martinez et al. 2016). Thus, gender-specific preferences (Croson and Gneezy 2009) are one potential underlying factor impacting IPR gender gaps. Recently, Falk et al. (2018) documented with extensive data (Global Preference Survey) that there exists systematic differences in preferences across countries and between genders. Future studies could investigate to what extent country-level differences in preferences (e.g., women's generally higher risk aversion) are associated with educational and occupational choices and varying IPR gender gaps across countries.

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Appendix

See Table 3 and Figs. 3 and 4.

Table 3 Gender and team size

Dependent variable	Teamsize	Teamsize	Teamsize
Sample	Patent	UM	Design
Model	Negative binomial	Negative binomial	Negative binomial
Estimate	Coeff.	Coeff.	Coeff.
Female name	0.38*** (0.04)	0.39** (0.18)	0.11*** (0.04)
Non-individual applicant	0.15*** (0.04)	0.35*** (0.05)	0.11*** (0.04)
Constant	0.78*** (0.10)	0.14*** (0.04)	0.31* (0.23)
Year fixed effects	Yes	Yes	Yes
Technology field fixed effects	Yes	Yes	
Locarno class fixed effects			Yes
N	80,702	14,285	7298
Log pseudolikelihood	− 158,463.19	− 21,870.44	− 9537.65

In all samples the period is 1992–2013. Inventors and designers for which gender could not be attributed are excluded. Standard errors clustered at the filing level in parentheses. ***, **, and * indicate 0.01, 0.05, and 0.1 significance level, respectively

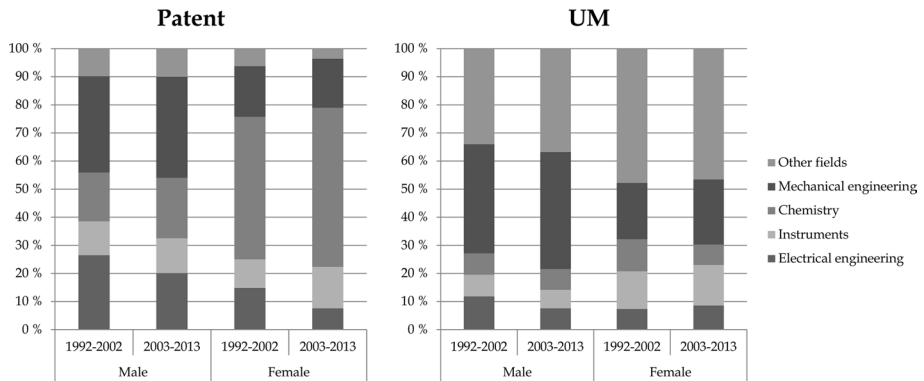


Fig. 3 Specialization by gender. *Notes:* Technology classification is based on the main/first IPC class of each patent and UM using the WIPO’s IPC concordance table (sector). Available at: http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/xls/ipc_technology.xls (March 2018 update)

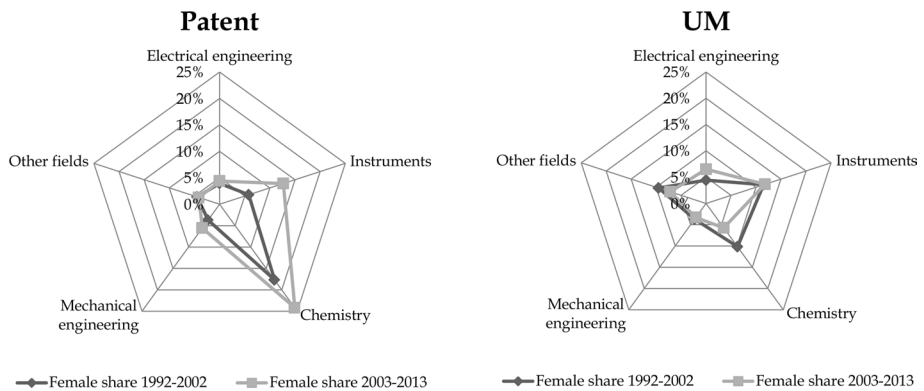


Fig. 4 Gender gaps by technology sectors over time. *Notes:* Technology classification is based on the main/first IPC class of each patent and UM using the WIPO’s IPC concordance table (sector). http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/xls/ipc_technology.xls. March 2018 update

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